Fillable cushion and method and apparatus for producing a cushion

The invention relates to a fillable cushion, a method and an apparatus for fabricating fillable cushions, in particular inflatable cushions, in which at least two plastic films are welded to one another along a contour of the cushion in such a way that a fillable cavity is produced, and also a method and an apparatus for filling empty cushions with gas.

Cushions and combinations of cushions which protect the corners and/or the edges of cuboidal articles to be packed are known, see for instance WO 98/23502. However, these cushions have the disadvantage that only the edges and the corners are protected; the surface areas remain unprotected, which in particular in the case of large articles does not offer the necessary protection for instance on the underside or the upper side of the articles.

US 5 803 263 A, US 6 244 441 B1 and WO 98/29319 show cushions which additionally protect one surface area of a cuboidal article.

It is therefore an object of the present invention to provide a cushion which is as simple and easy to attach as possible and which surrounds not only edges and corners but also at least one surface area of the article to be protected.

The object is achieved by a cushion according to Claim 1. With this, four corners, two edges and a surface area of the article can now be cushioned, the cushion being held in position at two corners by the recesses at its longitudinal ends. With two of these cushions, all the corners of the article can be cushioned and, if appropriate, two surface areas in addition, that is for instance the base area, on which the article rests in the package, for instance a box, and the top area.

In order that the cushion can be brought around the corners of the article when it is later placed around the article, it may be provided that the cushion comprises a number of part-cushions, in particular

with chambers that are separate from one another. That is to say, for instance, it comprises a part-cushion which has a closed fillable chamber for the first edge to be protected and a further part-cushion which likewise has a closed fillable chamber for the second edge to be protected. Between the part-cushions, the cushion can then be bent and brought around the corner. It would also be possible for the two part-cushions to have a common fillable chamber. On the other hand, the individual part-cushion could also itself have a number of fillable chambers, which increases the reliability if one chamber should happen to leak.

One possible embodiment provides that respectively provided for the edge to be protected is a part-cushion, which has a recess by which the part-cushion can be fitted onto the edge to be protected. This is achieved, for instance, by rectangular ring cushions, the recess of which is essentially as long as the edge of the article to be protected.

In this case, the two part-cushions may be connected to one another by a band or by a further part-cushion. The band has the advantage that it can be easily produced, but the disadvantage that it can only protect the spanned surface area of the article to a limited extent, so these areas are mainly protected by the part-cushions protruding over the edges. A further part-cushion between the two part-cushions for the two edges has the advantage that the spanned surface area of the article is likewise cushioned and held in position with respect to a package in which the article is arranged together with the cushion.

In order that the part-cushions for the edges remain better in position on them, it may be provided that, in the case of at least one part-cushion, the recess has a smaller width in the centre than at the ends. Then the part-cushion no longer has, for example, the form of a rectangle, but instead the sub-regions of the cushion that are arranged along the edge of the article are brought towards one another, so that the rectangle approximates the shape of an "8".

A further object of the invention is to provide a method and an apparatus for producing cushions (fabricating and inflating).

Fabricating is understood as meaning producing weld seams along the desired contours of the cushion. It is known from the prior art to use thermal welding methods for fabricating fillable cushions. These methods have the disadvantage that the quality of the weld seams is not satisfactory due to the relatively large heat influencing zone of the dies that are used. This may cause hairline cracks to form in the plastic film, through which air can later escape. Moreover, the use of dies makes the method inflexible; only large quantities of one and the same cushion can be produced cost-effectively.

It is known from WO 00/44644 A1 to use ultrasonic welding for producing packaging cushions.
It is therefore an object of the invention to provide an alternative method for welding plastic films which overcomes this disadvantage.

This object is achieved by the method according to Claim 9 and by the apparatus according to Claim 15.

Ultrasonic welding has so far been used mainly for welding non-deformable plastic mouldings, which have considerably greater thicknesses (> 1 mm).

The basis of the principle of ultrasonic welding is that ultrasonic vibrations are transmitted into a sonotrode from a generator. The sonotrode transmits the ultrasonic vibrations to the plastic films and is pressed onto the plastic films arranged on a planar supporting surface (for example a glass plate). The ultrasonic vibrations produce frictional heat at the joining surfaces of the plastic films and induce viscous flow in the plastic film. After cooling, the welded connection is solid.

Plastic films are understood here as being thermoplastics which have a thickness of at most 200 µm. The preferred thickness for high-strength inflatable cushions lies between 80 and 150 µm, in particular

at 90 µm. Examples of films which can be used are HD-PE (high-density polyethylene, has low gas permeability), or composite films with a solid layer which is as impermeable to gas as possible, which usually can be welded poorly (for example polyamide films, PA), and a layer which can be welded well (for example polyethylene films, PE), that is for instance PA-PE films.

For the cushions that are produced to be used as air cushions in the packaging industry, the use of such plastic films with high strength and low gas permeability is an important prerequisite, since the cushions are used there for fixing articles in containers, for absorbing impact and vibrations, and for filling cavities in packages. These functions must be maintained even when the cushions are stored for a considerable time (the cushions must not lose too much air) or when they are subjected to impact loading, low outside pressure and/or extreme temperature fluctuations (transport by aircraft).

Apart from gas, however, the cavity of the cushion may also be filled with some other fluid, that is to say with a liquid or with a gel.

Suitable as the starting material for cushions are not only individual separate plastic films but also a folded-together plastic film or a tube.

Ultrasonic welding can in principle be performed in two ways: by moving a sonotrode along the contour of the cushion, in particular linearly in three spatial axes, or by leaving a sonotrode for a period of time on the plastic film, that is to say, for instance, pressing a sonotrode onto the plastic film as a die which has the shape of the weld seam to be produced and is movable perpendicularly to the welding plane. The period of time is dependent on the thickness and the melting point of the plastic film.

The first variant has the advantage that any desired contour can be produced, which makes it favourable for use for the cushions according to the invention, because specific cushions must be produced here for every article with different dimensions. The second variant is

advantageous if the same contour is to be produced often, which can be performed much more quickly than if the contour has to be passed over several times by a sonotrode.

In the case of the first variant, it is according to the invention provided that, in the case of curved contours, the sonotrode is rotated about an axis perpendicular to the welding plane in such a way that the sonotrode is aligned tangentially in relation to the contour. This ensures that the sonotrode is always aligned in the direction of the weld seam, which ensures a proper weld seam with consistent quality.

It is also of advantage in the case of the first variant if the movement of the sonotrode is electronically controlled on the basis of any given contour. For instance, the contour may be stored in a file on a computer and be passed on directly to the control device of the sonotrode. For this purpose, the control device may be connected for example to a CAD station.

The first variant can be carried out with the aid of a so-called plotter. The ultrasonic welding device is mounted on the said plotter and can be moved linearly in space along three axes perpendicular to one another, with the possibility of rotation about the axis perpendicular to the welding plane being additionally provided.

In order that a particularly uniform weld seam is produced, it may be provided for both variants of ultrasonic welding that the contact pressure with which the sonotrode is pressed against the plastic films is regulated. This ensures a constant contact pressure and a consistent quality of the weld seam.

In order that the cushions can be easily detached from the surrounding material (other cushions, remaining plastic film) after the weld seam has been produced, one embodiment of the invention provides that a perforation or a severing cut is produced in the plastic film by the sonotrode. For this purpose it is possible to use a sonotrode with a number of blades, at least one of which is formed for welding and at

least one is formed for cutting or for producing a perforation (for example a severing notch, along which the cushion can later be detached from the surrounding material). In this way, the welding and the cutting-out/perforating of the cushion outside the weld seam can be performed in one working step.

In principle, the sonotrode may also have two or more blades just for welding, so that a number of parallel weld seams are produced simultaneously.

In order to obtain an opening for easy inflation, it may be provided that, before or after the welding, at least one plastic film is given at least one punched clearance for each cushion. Through this punched clearance, the cushion can later be filled by an apparatus which is arranged outside the plane of the cushion, for instance above the plane of the cushion. Inflation is in this case possible both with a complete punched clearance (through all the plastic films) and with a punched clearance in only one plastic film.

Finally, it may be provided in the case of the method according to the invention that only one open weld seam is produced, that is to say the cushion is not closed, in order that it can be filled through the interruption in the weld seam. In this case, a punched clearance would then be provided outside the contour of the cushion, in order that the cushion can be filled through this punched clearance and through the interruption in the weld seam.

If a closed weld seam is produced, the punched clearance must be arranged inside the contour of the cushion, preferably near the weld seam, in order that it can be filled. After filling, the cushion may be closed, in that the region with the punched clearance is separated from the remaining filled volume of the cushion by a further weld seam.

With the apparatus and the method according to the invention it is possible to produce a fillable cushion in which at least two layers of plastic films are welded to one another along a contour of the cushion

in such a way that a fillable cavity is produced, the weld seam being interrupted at one location for the purpose of filling. In this case, an opening for the filling of the cushion is provided in at least one plastic film, outside the fillable cavity in the region of the interrupted location, tangentially in relation to the contour of the cushion.

This has the advantage that the arrangement of the opening near the interrupted location allows the gas to reach the cushion over a short path and the closing of the weld seam along the given contour at the same time allows the inflation opening to be closed.

The cushions produced according to the invention can be easily filled by a method according to the invention and an apparatus according to the invention, as they are respectively presented in Claims 23 and 30. This is applicable both when the empty cushions are already in the form of separate cushions and when the cushions are merely in the form of weld seams on a continuous sheet of at least two plastic films welded to one another. The latter has the advantage that the sheet can be transported more easily in the apparatus for filling than individual cushions can.

The invention provides that at least one nozzle is arranged at a distance from an opening, in particular a punched clearance, in one of the plastic films of the cushion, obliquely in relation to the surface area of the cushion or its bearing surface, and gas is blown out of this nozzle onto the opening.

In the case of previous methods, for filling, the nozzle either had to be inserted into an opening specifically produced in one of the plastic films or had to be inserted between the plastic films through an interruption in the weld seam, see for instance WO 01/70593, Figure 1, which shows a filling opening 136 specifically formed by weld seams. The use of valves is also known from the prior art, see for instance WO 98/23492.

With the method according to the invention, contact does not have to be established between the nozzle and the cushion, so that it is possible to dispense with the operation of inserting the nozzle and, as a result, the filling can be performed more quickly. Furthermore, the geometry of the nozzle is kept more simple, since it does not have to be made to match a specific shape of the filling opening.

The nozzle thereby forms an angle of between 5° and 60°, preferably between 15° and 40°, with the plane of the empty cushion.

In order to ensure in a simple way that a defined amount of gas is contained in each cushion, it may be provided that a predetermined amount of gas is blown out from the nozzle for each opening. This can be achieved for instance by the gas in a supply container having a defined pressure and being fed to the nozzle for a defined time. The pressure in a filled cushion usually lies below 1 bar of positive pressure; the positive pressure in the cushion is normally 0.2-0.6 bar. During inflation, a state of equilibrium is reached, dependent on the nozzle geometry and the distance between the nozzle and the opening. It is possible to use, for instance, the compressed air network of a plant, which normally provides a pressure of approximately 6 bar, with it being possible to reduce the pressure to 2-3 bar by a pressure regulator, which has proven in practice to be favourable for the inflation.

Or it is possible to use a height sensor or a height limiter, which measures the height of the inflated cushion and switches off the supply of gases when a specific value or the given limitation is reached.

Furthermore, it may be provided that the cushion is stably held at at least two points during the inflation. This may take place either by means of two dies with a small bearing surface, which press the cushion, one on each side of the opening, for instance at the edge of the film outside the weld seam, against the underlying support and hold it in place.

After the inflation, the cushion is closed by means of welding. This welding is carried out according to where the opening for inflation was arranged: if the opening is arranged outside the contour of the cushion in front of an interruption in the weld seam, the interruption in the weld seam is closed by the welding following the contour of the cushion. If the opening lies within the contour of the cushion, at least the opening is separated from the remaining volume of the cushion by the welding. This can be performed by means of ultrasonic welding, but for the sake of simplicity this welding may also be performed thermally, for instance in the form of a die which is pressed onto the cushion for a specific period of time.

It is advantageously provided in this case that the location of the cushion that is to be welded is rendered pressureless during the welding. A specific die may be provided for this purpose, and be used to squeeze out the region around the opening, so that the gas located in the cushion cannot exert a pressure on the opening during the welding and shortly thereafter (until after cooling). This may take place, for instance, by means of a die with a curved contour, which is pressed with the curvature towards the filled cushion onto the weld seams existing on both sides of the opening.

If it is intended to inflate cushions with different geometries, in which for instance the distance between the opening and the interruption in the weld seam or the diameter of the opening differs, it may be necessary to pivot the nozzle, that is to say to change the angle between the nozzle and the plane of the cushion, and/or to change the distance of the nozzle from the plane of the cushion.

In order to achieve a jet for inflation that is as parallel as possible and does not diverge excessively, it has been found to be advantageous if the ratio of the diameter of the nozzle at the gas outlet to the distance of the nozzle from the opening of the cushion is between 1:3 and 1:10.

When the cushion is being inflated, it must be taken into account that the cushion, and with it also the openings, lift off from the

underlying support and, as a result, the distance from the nozzle is changed, so that the distance of a nozzle that is not moved in relation to the cushion during the inflation from the plane of the cushion of the empty cushion is to be chosen correspondingly, in order that the nozzle is also still at the optimum distance from the changed position of the opening during the inflation.

If the position of the opening of the cushion changes very greatly during the inflation on account of the cushion geometry (for example a high cushion), it is advisable to make the nozzle of a movable design, so that it can be both pivoted, in order to change the angle between the nozzle and the plane of the empty cushion, and displaced in the sense of a translatory movement, in order to change the distance from the cushion.

The invention is explained on the basis of the accompanying Figures 1 to 7, which represent the apparatuses according to the invention by way of example and schematically, and the descriptions which follow. In the drawing:

Figures 1 and 2	show cushions according to the invention with part-cushions which are connected by means of a band,
Figures 3 and 4	show cushions according to the invention with part-cushions which are connected by means of a further cushion,
Figure 5	shows a fabricator,
Figure 6	shows an inflator,
Figure 7	shows a longitudinal section through an inflator as shown in Figure 6.

Represented in Figures 1 to 4 is an article 19 to be packed, here a multimedia device (for example a video recorder, DVD player,...), on which two cushions according to the invention are fitted. The article with the cushions can be packed in a box which is made to match the article with the cushions, with respect to the inside dimensions, in such a way that the said article is fixed in the box. In this case, a

number of cushioned articles may also be packed into a box one above the other and/or one next to the other.

In Figure 1, the cushioned article 19 is shown obliquely from above in the upper representation and obliquely from below in the lower representation. The front side of the article 19 is identified by the buttons located on it. The two cushions 20, 21 respectively comprise two part-cushions for the edges to be protected, referred to hereafter as edge cushions 16 for short. These edge cushions are connected to one another by a band 18 on each side. In the figures, the edge cushions 16 are represented by contour lines to illustrate their shape.

The cushion 21 protects with one edge cushion 16 the left-hand, rear vertical edge and the two left-hand, rear corners of the article 19, with the other edge cushion 16 the right-hand, front vertical edge of the article 19 with the associated corners. The band 18 is passed over the upper side of the article 19. The cushion 20 protects with one edge cushion 16 the left-hand, front vertical edge and the two left-hand, front corners of the article 19, with the other edge cushion 16 the right-hand, rear vertical edge of the article 19 with the associated corners. The band 18 is in this case passed over the underside of the article 19.

The band comprises two layers of non-welded plastic film, so that the entire cushion 20, 21 can be produced from one piece of plastic film. The edge cushions 16 may, however, also be produced as independent, individual cushions and be connected by a band on each side before or after the inflation.

In Figure 2, the cushioned article 19 is shown from the front in the upper representation and from above in the lower representation. Here it can be seen that the band 18 is stretched between the two edge cushions 16 and does not rest on the article 19, so that the stretched band acts as a protection for the surface area underneath it (upper side or underside of the article 19).

In Figure 3, the cushioned article 19 is again shown obliquely from above in the upper representation and obliquely from below in the lower representation. The two cushions 30, 31 respectively comprise two edge cushions 26, which are connected to one another by a surface cushion 17 on each side, with a flat, band-like region 27 being provided between the surface cushion 17 and the two edge cushions 26.

The surface cushion 17 has an annular filled border, which is adapted in the outer dimensions to the shape of the article 19. In the inner region, the plastic film is not cut out along the contour of the cushion, as in the case of the edge cushions 16, 26, but instead this is retained. Accessories for the article 19, for instance cables, operating instructions, remote controls, may be transported in the depression 28 in the inner region. The plastic film acts here as a protective layer between the accessory parts and the article 19.

It goes without saying that the surface cushion 17 may also be formed such that it can be inflated over the entire surface area, has a number of chambers that are connected or separate from one another or else have a number of depressions 28 which can be adapted in their shape to the individual accessory parts, that is to say enclose them for instance with a form fit.

The cushion 31 protects with one edge cushion 26 the left-hand, rear vertical edge and the two left-hand, rear corners of the article 19, with the other edge cushion 26 the right-hand, front vertical edge of the article 19 with the associated corners. The surface cushion 17 rests on the upper side of the article 19. The cushion 30 protects with one edge cushion 26 the left-hand, front vertical edge and the two left-hand, front corners of the article 19, with the other edge cushion 26 the right-hand, rear vertical edge of the article 19 with the associated corners. The associated surface cushion 17 rests on the underside of the article 19.

The edge cushions 26 have a constriction in the centre, so that the edge cushion has assumed the outer shape of an "8". The surface area surrounded by the edge cushion has a smaller width lengthwise in the

centre of the edge cushion than at the ends, although the cross sections of the annular edge cushion are not less at the centre of the edge cushion than at the upper end or lower end.

The band-like region 27 comprises two layers of non-welded plastic film, so that the entire cushion 30, 31 can be produced from one piece. The edge cushions 26 and the surface cushion 17 may, however, also be produced as independent, individual cushions and be connected by a band on each side before or after the inflation.

In Figure 4, the cushioned article 19 is shown from the front in the upper representation and from above in the lower representation.

It goes without saying that the configurations in Figures 1, 2 on the one hand and Figures 3, 4 on the other hand can be combined with one another. Straight edge cushions 16 can be combined with surface cushions 17 to form an overall cushion, constricted edge cushions 26 can be combined with bands 18.

It should also be mentioned that the edge cushions 16, 26 can also be fitted as protection on their own, without being connected to one another, onto the edges of an article to be protected.

In Figure 5, a fabricator according to the invention, for producing weld seams along the desired contours of the cushion, is represented. Weld seams 3 are produced from two plastic films 22, 23 wound up on rollers, by welding by means of an ultrasonic welding device 4 (welding device for short), which has a sonotrode 5. The plastic films 22, 23 are in this case fed discontinuously to the welding device 4 by means of drives and guiding rollers (not represented), with it being possible for openings 7 to be punched into the upper plastic film 22 at a first punching gantry 24. If both plastic films 22, 23 are to be punched through, the first punching gantry 24 does not go into operation, but instead the punching is carried out by a second punching gantry 25.

The welding is performed on a bearing surface 29, which is intended to be planar, smooth and as far as possible not elastic, for instance on a glass plate. The welding device 4 is arranged on a gantry 2, which like a plotter can be made to move in all three spatial directions in relation to the bearing surface 29, which is indicated by the double-headed arrows. In this way, weld seams 3 of any desired shape can be produced. Arranged next to the welding device 4 is a motor 6, which sets the sonotrode 5 about the axis perpendicular to the welding plane, so that the sonotrode is always aligned tangentially in relation to the contour. As soon as all the weld seams 3 have been completed over the width of the plastic films 22, 23, the latter are transported further, normally by the length of one cushion, so that the next cushions can be produced with the plastic film at rest.

Since in the case of the example in Figure 5 the openings 7 are located outside the contour of the cushions, the weld seam 3 remains open for the later filling of the cushions.

The prefabricated plastic film 9 is subsequently either rolled up or folded.

Represented in Figure 6 is an inflator according to the invention, which serves for inflating prefabricated empty cushions. These are rotatably mounted on the inflator as a roll 10 of prefabricated plastic film 9. In this example, two identical, essentially rectangular ring cushions 1 with rounded corners are respectively arranged next to one another over the width of the film, the corresponding weld seams 3 only being represented over half of the plastic film 9 for the sake of simplicity. Already provided between the individual cushions is a perforation 15, along which the cushions can be separated from one another. For each cushion, the weld seam 3 has in the region of the opening 7 an interruption through which the cushion can be inflated.

Provided for closing this interruption is a welding die 11, which has a rectangular die area, with which the interruption in the weld seam 3 can be closed by the effect of heat, it being possible for the welding

die 11 to be lowered from its position of rest at a distance from the cushion into the welding position, as represented in Figure 6. Before the welding, however, the location to be welded must be rendered pressureless with a further die 12. Therefore, firstly the die 12 is lowered from the represented position of rest onto the cushion 1, then the welding die 11 is lowered onto it, the said welding die being moved up again after the welding, while the die 12 remains pressed on the cushion until the weld seam has cooled and can be subjected to loading.

Both dies 11, 12 can be displaced along a beam 13 and can be fixed on the beam, so that the dies can be set to various cushion geometries and film widths. It is also possible for two or more dies 11, 12 and nozzles 8 to be arranged on the beam 13, so that a number of cushions can be inflated simultaneously.

In order that the prefabricated plastic film 9 does not slip during the inflation, it is possible to provide to the left and right of the dies 11, 12, with respect to the direction of the beam 13, further dies, which press the plastic film 9 against the underlying support in the region between the weld seam 3 and the perforation 15 to the left and right of the opening 7.

In Figure 7, a longitudinal section through an inflator as shown in Figure 6 is represented, the section extending through the opening 7, and only the region around the dies 11 and 12 and the nozzle 8 being represented. The prefabricated plastic film 9 is transported by guiding rollers 14 and advanced to the extent that the opening 7 of the cushion comes to lie at the point of impingement of the jet of the nozzle 8, the gas supply line of which is not represented. If this point is reached, the plastic film 9 is stopped and gas is blown into the opening through the nozzle. In this exemplary embodiment, the nozzle has an angle with the plane of the cushion which lies between 25° and 35°.

The opening 7 is provided at least in the form of a punched clearance in the upper layer of the prefabricated plastic film 9, but the

cushions can also be inflated if two layers of plastic film 9 have been punched through. The latter has the advantage that it is also possible for the opening 7 to be produced in the prefabricated plastic film 9, while otherwise the opening has to be produced in only one layer before fabrication. If both layers of the plastic film 9 have been punched through, it may be necessary for the inflation to provide a device which makes it possible to separate the two plastic films, that is to say for instance holds the lower plastic film in place, so that the upper plastic film can be lifted off by the gas pressure.